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(54) Title: METHODS AND FABRICS FOR COMBATING NOSOCOMIAL INFECTIONS

(57) Abstract: The invention provides a method for combating and preventing nosocomial infections, comprising providing to health care facilities textile fabrics incorporating fibers coated with an oxidant, cationic form of copper, for use in patient contact and care, wherein the textile fabric is effective for the inactivation of antibiotic resistant strains of bacteria.

or bactericide. Second, multiple launderings tends to weaken the binder or adhesive and loosen or remove the particles.

Two notable exceptions to the general rule that metals and metal oxides have not heretofore been bonded directly to textiles are nylon textiles and polyester textiles, which may be plated with metals using standard electrolyses plating processes for plating plastics. The specific electrolyses plating methods known to the art are restricted in their applicability to only certain plastics, however. In particular, they are not suited to natural fibers, nor to most synthetic fibers.

With this state of the art in mind, both of said publications taught various aspects of a textile with a full or partial metal or metal oxide plating directly and securely bonded to the fibers thereof.

More specifically, in WO 98/06509 there is provided a process comprising the steps of: (a) providing a metallized textile, the metallized textile comprising: (i) a textile including fibers selected from the group consisting of natural fibers, synthetic cellulosic fibers, regenerated fibers, acrylic fibers, polyolefin fibers, polyurethane fibers, vinyl fibers, and blends thereof, and (ii) a plating including materials selected from the group consisting of metals and metal oxides, the metallized textile characterized in that the plating is bonded directly to the fibers; and (b) incorporating the metallized textile in an article of manufacture.

In the context of said invention the term "textile" includes fibers, whether natural (for example, cotton, silk, wool, and linen) or synthetic yarns spun from those fibers, and woven, knit, and non-woven fabrics made of those yarns. The scope of said invention includes all natural fibers; and all synthetic fibers used in textile applications, including but not limited to synthetic cellulosic fibers (i.e., regenerated cellulose fibers such as rayon, and cellulose derivative fibers such as acetate fibers), regenerated protein fibers, acrylic fibers, polyolefin fibers, polyurethane fibers, and vinyl fibers, but excluding nylon and polyester fibers, and blends thereof.

Said invention comprised application to the products of an adaptation of technology used in the electrolyses plating of plastics, particularly printed circuit boards made of plastic, with metals. See, for example, Encyclopedia of Polymer Science and Engineering (Jacqueline I. Kroschwitz, editor), Wiley and Sons, 1987, vol. IX, pp 580-598. As applied to textiles, this process included two steps. The first step was the activation of the textile by precipitating catalytic noble metal nucleation

the composition of matter characterized by catalyzing the reduction of at least one metallic cationic species to a reduced metal, thereby plating said fibers with said reduced metal.

In addition, said publication teaches and claims processes for producing said products.

A preferred process for preparing a metallized textile according to said publication comprises the steps of:

a) selecting a textile, in a form selected from the group consisting of yarn and fabric, said textile including fibers selected from the group consisting of natural fibers, synthetic cellulosic fibers, regenerated protein fibers, acrylic fibers, polyolefin fibers, polyurethane fibers, vinyl fibers, and blends thereof;

b) soaking said textile in a solution containing at least one reductant cationic species having at least two positive oxidation states, said at least one cationic species being in a lower of said at least two positive oxidation states;

c) soaking said textile in a solution containing at least one noble metal cationic species, thereby producing an activated textile; and

d) reducing at least one oxidant cationic species in a medium in contact with said activated textile, thereby producing a metallized textile.

While the metallized fabrics produced according to said publications are effective acaricides, it was found that they are also effective in preventing an/or treating bacterial, fungal and yeast infections which afflict various parts of the human body and that therefore the incorporation of at least a panel of a metallized textile material in an article of clothing can have extremely beneficial effect.

Thus, in US Patent 6,124,221 there is described and claimed an article of clothing having antibacterial, antifungal, and antiyeast properties, comprising at least a panel of a metallized textile, the textile including fibers selected from the group consisting of natural fibers, synthetic cellulosic fibers, regenerated protein fibers, acrylic fibers, polyolefin fibers, polyurethane fibers, vinyl fibers, and blends thereof, and having a plating including an antibacterial, antifungal and antiyeast effective amount of at least one oxidant cationic species of copper.

In said specification there was described that said article of clothing was effective against *Tinea Pedis,* against *Candida Albicans,* against *Thrush* and

turn the fabric into an active antimicrobial/anti-virus active device. By treating the fabrics used in the hospital or ward with an effective germicide, one should be able to limit the spread of live bacteria throughout the location, thus limiting the spread of disease.

Thus, according to the present invention there is now provided a method for combating and preventing nosocomial infections, comprising providing to health care facilities textile fabrics incorporating fibers coated with an oxidant, cationic form of copper, for use in patient contact and care, wherein said textile fabric is effective for the inactivation of antibiotic resistant strains of bacteria.

In preferred embodiments of the present invention said textile fabrics are formed into articles of bedding, articles of wear for patients, and articles of wear for health care personnel.

In especially preferred embodiments of the present invention said articles of bedding include sheets, pillow cases and blanket covers, said articles of wear for patients include pajamas and nightgowns and said articles of wear for healthcare personnel include uniforms. The invention also includes other textile products found in hospitals and similar facilities such as divider curtains.

In another aspect of the invention there is also provided textile fabrics for combating and preventing nosocomial infections in healthcare facilities, said fabrics incorporating fibers coated with an oxidant, cationic form of copper, for use in patient contact and care, wherein said textile fabric is effective for the inactivation of antibiotic resistant strains of bacteria.

The fabric can be made of almost any fiber, however, a certain percentage of the fibers in the yarn from which the fabric is made, is treated so that the fibers are coated with an ionic form of copper, e.g., CuO or Cu_2O. The copper is deposited through an oxidation reduction process on the fibers. The treated fibers are then mixed with regular untreated fibers and spun into yarns for introduction into a textile fabric.

Oxidation reduction of ionic copper onto cotton, Lyocell (recycled cellulose), as well as most commonly used textile polymers was found to create a bond between the copper and the surface of the fibers which is able to withstand at least twenty home launderings.

A dilute basic $CuSO_4$ solution was prepared by dissolving $CuSO_4$ and NaOH (in approximately equal weight proportions), a chelating agent, and polyethylene glycol in water.

The activated cotton fabric and formaldehyde were added to the $CuSO_4$ solution under a pure oxygen atmosphere. After between 2 minutes and 10 minutes, the cotton fabric was removed.

The palladium deposited on the cotton fabric in the activation step catalyzed the reduction of the Cu++ by the formaldehyde, providing a layer of copper tightly and intimately bonded to the fibers of the cotton fabric. The fabric, which initially was white in color, now as the color of copper metal, while retaining the flexibility and physical characteristics of the original fabric. The metallic copper color remained unchanged after several launderings.

The configuration of the bath is such that in the Copper Sulfate step the fabric is set up vertically and not in the tradition horizontal pile to allow a clean reduction on to the fabric surface of the desired copper. The vertical positioning of the fabric is done with the aid of or plurality of poles set up on a frame in an array similar to two spaced-apart rung ladders with the poles acting as said rungs. The fabric is interwoven in a repeating switchback array on the poles of the frame in such a way that at no place does the fabric touch other parts of the fabric. This configuration also allows the escape of gases as the chemicals react with one another thereby yielding a clean copper reduction on the fabric.

EXAMPLE 2

The procedure of Example 1 was repeated using cotton yarn in place of cotton fabric. Yarn for weaving into a woven cloth was prepared from fibers which received 100% coating, which treated fibers were then combined in a ratio of 20 w/w% with 80% untreated fibers to form a yarn containing 20% copper. These yarns were then introduced as the weft (fill) yarn with warp threads, which were untreated, to produce panels of fabric containing 10% Cu++. This fabric was then tested for anti-microbial activity, the results of which are reported in Examples 3 and 4 hereinafter.

EXAMPLE 3 Anti-microbial activity of treated textile against nosocomial strain of Staph A.

Method: AATCC Technical Manual. Test Method 100-1993

Microbial Monitoring Procedure: Pour Plate Method

Temperature and Time of Incubation: 37 °C / 48 Hours

ASSAY RESULTS

Inoculum Control on TSA + Tween 80 + Lecithin: 2.88 X 10^4 c.f.u. / ml

Samples	**c.f.u. / sample**		
	Time of Exposure 35°C		**Reduction Percentage**
	0	**1 hour**	
Washed 10% / Cu^{++} Treated Woven cloth	2.76 X 10^4	1.5 X10^2	99.5%
Washed Untreated Woven White Cloth	2.88 X 10^4	2.2 X 10^4	23.6%

c.f.u. = Colony Forming Unit

From the above Examples 3 and 4, it is seen that indeed the products of the present invention are effective for combating and preventing nosocomial infections.

Having demonstrated the surprising effectiveness of the products of the present invention against nosocomial infections, further experiments were carried out on the safer strain of *Staphylococcus Aureus* - ATCC 6538 in order to determine the amount of fibers coated with an oxidant cationic form of copper necessary to obtain significant results.

More specifically, woven white cloth of a cotton polyester blend, having a weight of 150 g/m^2 was prepared, wherein the warp yarns were untreated, while the weft (or fill) yarns were treated yarns according to the present invention and instead of replacing all of the weft yarns with treated yarns having a 20% content of Cu^{++}, as was the case of the cloth tested in Examples 3 and 4, either every other yarn, every fourth yarn, or every sixth weft yarn was replaced by a 20:80 mixed treated yarn according to the present invention. Cloths prepared in this manner were then designated, respectively, as X2, X4 and X6 CU^{+2} and submitted for testing.

thereof, and it is therefore desired that the present embodiments and examples be considered in all respects as illustrative and not restrictive, reference being made to the appended claims, rather than to the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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synthetic cellulosic fibers, regenerated protein fibers, acrylic fibers, polyolefin fibers, polyurethane fibers, vinyl fibers, and blends thereof, said fibers having a coating of at least one cationic species of copper produced by a first step of soaking said fibers in a solution of a low-oxidation state reductant cation, then in a solution of noble metal cations to produce activated nucleation sites on the fibers; followed by a third step of introduction of a reducing agent and a copper salt, in close proximity to the activated fibers, to produce copper cations, which plate the fibers with a cationic species of copper to provide the same with antibacterial properties effective for the inactivation of antibiotic resistant strains of bacteria, said treated fibers being mixed with regular untreated fibers to form said textile fabric.

9. A textile fabric according to claim 6 for combating and preventing nosocomial infections in healthcare facilities, wherein the cationic species of copper comprises Cu^{2+} ions which are supplied from a copper sulfate solution.

10. A textile fabric according to claim 8 for combating and preventing nosocomial infections in healthcare facilities, wherein the reducing agent is formaldehyde.

11. The use of fibers coated with a cationic form of copper for the manufacture of a textile fabric for combating and preventing nosocomial infections in healthcare facilities, said fabric incorporating fibers coated with a cationic form of copper, for use in patient contact and care, wherein said textile fabric is effective for the inactivation of antibiotic resistant strains of bacteria.